Competencies for Teachers: Chemistry: Grades 7-12

2021

In addition to the Arkansas Teacher Standards, the Chemistry Teacher, Grades 7-12, shall demonstrate knowledge and/or competencies in the following areas:

1. Content Knowledge *NSTA/ASTE: Standard 1* *NRC Framework* *Praxis (5245)* *ACS* *NSTA-C* *AR SS*	***NSTA/ASTE Standard 1:*** *Effective teachers of science understand and articulate the knowledge and practices of contemporary science and engineering. They connect important disciplinary core ideas, crosscutting concepts, and science and engineering practices for their fields of licensure* 1.1 Uses and applies major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields. Explains the nature of science and the cultural norms and values inherent to the current and historical development of scientific knowledge 1.2 Demonstrates knowledge of crosscutting concepts, disciplinary core ideas, practices of science and engineering, the supporting role science-specific technologies, and contributions of diverse populations to science 1.3 Demonstrates knowledge of how to implement science standards, learning progressions, and sequencing of science content for teaching their licensure level PK-12 students ***NRC Framework: Core Component Ideas in the Physical Sciences:*** 1.4 Core Idea PS1: Matter and Its Interactions PS1.A: Structure and Properties of Matter *Concepts include: chemical and physical properties, states of matter, phase changes, solutions, periodicity, bonding and intermolecular forces, physical changes, chemical changes, biological and common organic compounds* PS1.B: Chemical Reactions *Concepts include: chemical equations, solutions, reaction types, stoichiometry, kinetics, equilibrium* PS1.C: Nuclear Processes *Concepts include: nuclear chemistry* 1.5 Core Idea PS2: Motion and Stability: Forces and Interactions PS2.A: Forces and Motion *Concepts include: periodicity, atomic structure, molecular structure* PS2.B: Types of Interaction *Concepts include: bonding and intermolecular forces, attractions and repulsions, covalent bonding, types of chemical reactions* PS.2C: Stability and Instability in Physical Systems *Concepts include: kinetics, electrochemistry, materials: properties explained by molecular structure, colligative properties, chemical engineering*

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1.6 Core Idea PS3: Energy
PS3.A: Definitions of Energy
PS3.B: Conservation of Energy and Energy Transfer
Concepts include: thermochemistry, thermodynamics, equilibrium
PS3.C: Relationship Between Energy and Forces
Concepts include: bonding and intermolecular forces, electrochemistry, nuclear chemistry
PS3.D: Energy in Chemical Processes and Everyday Life
Concepts include: nature of science, chemical engineering,
1.7 Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer
PS4.A: Wave Properties
Concepts include: sound waves, light waves
PS4.B: Electromagnetic Radiation
Concepts include: electromagnetic radiation spectrum, atomic structure and Spectra,, the interactions between energy and matter, quantum chemistry
PS4.C: Information Technologies and Instrumentation
Concepts include: quantitative analysis (e.g, Beer's law)

The Principles of Chemistry include:
1.8 Demonstrates a deep understanding following active investigations in the principles of the conservation of electricity and magnetism of

- Atoms are not destroyed in chemical reactions; they are rearranged Forms of energy; energy changes in chemical reactions
- Stoichiometry and balancing chemical reactions

1.9 Demonstrate a deep understanding following active investigations in the principles of the behavior and properties of matter and energy of

- The periodic table of elements as the master organizer of chemistry
- Gas laws
- Distinguishing among elements, compounds, and mixtures
- Chemical bonding
- Intermolecular forces

1.10 Demonstrates a deep understanding following active investigations in the principles of the particulate nature of matter of

- Kinetic Molecular Theory
- Structure of atoms, ions, and molecules

	1.11 Demonstrates a deep understanding following active investigations in the principles of the equilibrium and driving forces of • Le Chatelier's Principles • Reaction rates • Thermodynamics (entropy and enthalpy) • Acid-base reactions • Redox reactions • Combustion
2. Content Pedagogy *NSTA/ASTE: Standard 2* *ACS* *AR SS*	***NSTA/ASTE Standard 2:*** *Effective teachers of science plan learning units of study and equitable, culturally responsive opportunities for all students based upon their understanding of how students learn and develop science knowledge, skills, and habits of mind. Effective teachers also include appropriate connections to science and engineering practices and crosscutting concepts in their instructional planning* 2.1 Uses science standards and a variety of appropriate, student-centered, and culturally-relevant science disciplinary-based instructional approaches that follow safety procedures and incorporate science and engineering practices, disciplinary core ideas, and crosscutting concepts 2.2 Incorporates appropriate differentiation strategies, wherein all students develop conceptual knowledge and an understanding of the nature of science. Lessons should engage students in applying science practices, clarifying relationships, identifying natural patterns and empirical experiences 2.3 Uses engineering practices in support of science learning wherein all students design, construct, test and optimize possible solutions to a problem 2.4 Aligns instruction and assessment strategies to support instructional decision making that identifies and addresses student misunderstandings, prior knowledge, and naïve conceptions Possible assessment types to use in instruction: *Summative assessments are performed in periodic intervals to assess a collection of knowledge at a particular point in time. Summative assessments may take the form of traditional assessments, including quizzes, exams, lab reports, and term papers but may also include projects, posters, presentations, etc.* *Student self-assessment could be in the form of a journal that is used to encourage students to reflect and assess their progress* *Performance-based assessments have proven to be effective in assessing three-dimensional learning. This requires students to demonstrate content knowledge (DCIs), the ability to make connections (CCCs), and developing solutions to solve a problem (SEPs)*

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	Model-based assessment allows students to demonstrate content knowledge. The creative diagramming aspect of the model means that students, especially English language learners (ELLs), can demonstrate content understanding without being bogged down by vocabulary; they can show their comprehension is deeper than vocabulary *Third party assessment tools have the advantage of being unbiased and statistically valid. Local, district, and state assessments may be examples of third-party assessments, including end-of-course exams. Some tools, such as those from the ACS Exams Institute, can provide objective national or regional performance rankings* 2.5 Integrates science-specific technologies to support *all* students' conceptual understanding of science and engineering
3. Learning Environments *NSTA/ASTE: Standard 3*	***NSTA/ASTE Standard 3:*** *Effective teachers of science are able to plan for engaging all students in science learning by identifying appropriate learning goals that are consistent with knowledge of how students learn science and are aligned with standards. Plans reflect the selection of phenomena appropriate to the social context of the classroom and community, and safety considerations, to engage students in the nature of science and science and engineering practices. Effective teachers create an anti-bias, multicultural, and social justice-learning environment to achieve these goals* 3.1 Plans a variety of lesson plans based on science standards that employ strategies that demonstrate their knowledge and understanding of how to select appropriate teaching and motivating learning activities that foster an inclusive, equitable, and anti-bias environment 3.2 Plans learning experiences for all students in a variety of environments (e.g., laboratory, field and community) within their fields of licensure 3.3 Plans lessons in which all students have a variety of opportunities to investigate, collaborate, communicate, evaluate, revise, and defend their own explanations of: scientific phenomena, observations, and data

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4. Safety *NSTA/ASTE: Standard 4* *Praxis (5245)* *ACS* *COSSS*	***NSTA/ASTE Standard 4*:** *Effective teachers of science demonstrate biological, chemical, and physical safety protocols in their classrooms and workspace. They also implement ethical treatment of living organisms and maintain equipment and chemicals as relevant to their fields of licensure* 4.1 Implements activities appropriate for the abilities of all students that demonstrate safe techniques for the procurement, preparation, use, storage, dispensing, supervision, and disposal of all chemicals/materials/equipment used within their fields of licensure 4.2 Demonstrates the awareness to recognize, prevent, and appropriately respond to hazardous situations(i.e. manage overcrowding; implement emergency procedures; maintain safety equipment; provide adequate student instruction and supervision; and follow policies and procedures that comply with established state and national guidelines, appropriate legal state (Arkansas Code Annotated § 6-10-113 [2012] for eye protection) and national safety standards (e.g., OSHA, NFPA, EPA), and best professional practices (e.g., NSTA, NSELA)) 4.3 Demonstrates ethical decision-making with respect to safe and humane treatment of all living organisms in and out of the classroom, and comply with the legal restrictions and best professional practices on the collection, care, and use of living organisms as relevant to their fields of licensure
5. Impact on Student Learning *NSTA/ASTE: Standard 5*	***NSTA/ASTE Standard 5:*** *Effective teachers of science provide evidence that students have learned and can apply disciplinary core ideas, crosscutting concepts and science and engineering practices because of instruction. Effective teachers analyze learning gains for individual students, the class as a whole, and subgroups of students disaggregated by demographic categories, and use these to inform planning and teaching* 5.1 Implements assessments that show *all* students have learned and can apply disciplinary knowledge, nature of science, science and engineering practices, and crosscutting concepts in practical, authentic, and real-world situations 5.2 Collects, organizes, analyzes, and reflects on formative and summative evidence and uses those data to inform future planning and teaching 5.3 Analyzes science-specific assessment data based upon student demographics, categorizing the levels of learner knowledge, and reflect on results for subsequent lesson plans

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6. Professional Knowledge and Skills *NSTA/ASTE: Standard 6* *New America*	***NSTA/ASTE Standard 6:*** *Effective teachers of science strive to continuously improve their knowledge of both science content and pedagogy, including approaches for addressing inequities and inclusion for all students in science. They identify with and conduct themselves as part of the science education community* 6.1 Engages in critical reflection on their own science teaching to continually improve their instructional effectiveness 6.2 Participates in professional development opportunities to deepen their science content knowledge and practices 6.3 Participates in professional development opportunities to expand their science-specific pedagogical knowledge ***New America:*** 6.4 Reflects on one's cultural lens 6.5 Recognizes and redresses biases in the system 6.6 Promotes respect for students' differences 6.7 Collaborates with families and the local community
7. Incorporates Crosscutting Concepts *NRC Framework* *Praxis (5245)*	7.1 Understands and exhibits knowledge of patterns 7.2 Understands and exhibits knowledge of cause and effect and mechanism and explanation 7.3 Understands and exhibits knowledge of scale, proportion, and quantity 7.4 Understands and exhibits knowledge of systems and system models 7.5 Understands and exhibits knowledge of energy and matter, flows, cycles, and conservation 7.6 Understands and exhibits knowledge of structure and function 7.7 Understands and exhibits knowledge of stability and change 7.8 Teacher candidates will facilitate opportunities for 7-12 students to identify and demonstrate understanding of these crosscutting concepts paired with the disciplinary core ideas and science and engineering practices

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8. Incorporates Science and Engineering Practices *NRC Framework* *Praxis (5245)*	8.1 Knows and practices the eight practices of science and engineering that the Framework (NRC) identifies as essential for all students to learn and describes in detail are listed below: • Asks questions (for science) and defining problems (for engineering) • Develops and uses models • Plans and carries out investigations • Analyzes and interprets data • Uses mathematics and computational thinking • Constructs explanations (for science) and designs solutions (for engineering) • Engages in argument from evidence • Obtains, evaluates, and communicates information 8.2 Teacher candidates will facilitate opportunities for 7-12 students to demonstrate application of the Science and Engineering Practices paired with the disciplinary core ideas and the crosscutting concepts
9. Incorporates History and Nature of Science *NRC Framework* *Praxis (5245)*	9.1 Applies appropriate practices and knowledge to show scientific investigations use a variety of methods 9.2 Applies appropriate practices and knowledge to show scientific knowledge is based on empirical evidence 9.3 Applies appropriate practices and knowledge to show scientific knowledge is open to revision in light of new evidence 9.4 Applies appropriate practices and knowledge to scientific models, laws, mechanisms, and theories that explain natural phenomena 9.5 Applies appropriate practices and knowledge to show science is a way of knowing 9.6 Applies appropriate practices and knowledge to demonstrate scientific knowledge assumes an order and consistency in natural systems 9.7 Applies appropriate use of scientific measurement and notation systems (i.e., precision vs accuracy, metric and SI units, unit conversions, scientific notation and significant figures, linear vs. logarithmic scales [e.g., pH]) 9.8 Teacher candidates will facilitate opportunities for 7-12 students to demonstrate application of the History and Nature of Science

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10. Anchoring Instruction in Phenomena *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom: National Academies Press*	10.1 Engages students in active science thinking 10.2 Helps students make connections and to understand how science ideas are important 10.3 Identifies phenomena that describe events or facts that can be observed, unusual or not 10.4 Engages student in making sense of novel phenomena to gain conceptual understanding of what they observe in the world 10.5 Elicits students' natural curiosity about something that can be explained scientifically 10.6 Develops a range of activities that allow students to develop three-dimensional understanding of the core ideas and cross cutting concepts while using science and engineering skills
11. Supporting Competencies *NSTA-C* *ACS* *AR SS*	11.1 *Mathematics:* • Understands mathematical and statistical models evaluate the strength of a conclusion • Understands how mathematical models used in chemistry • Understands what are the applications of calculus in chemistry • Understands how to use logarithms 11.2 *Earth and Space Science* • Understands how do Earth's major systems interact to impact Earth processes • Understands how humans depend on Earth's resources • Understands what human activities have positively and negatively impacted Earth's climate • Understands how the chemical and physical properties of water and its movement create changes in the surface and subsurface of the Earth • Understands what is the universe and what goes on in stars • Understands stars light spectra and brightness are used to identify compositional elements of stars, their movements, and their distances from Earth • Understands that studying lunar rocks, asteroids, and meteorites provide information about Earth's formation and early history • Understands that predictable patterns of planetary motion are caused by Earth's movement in the solar system

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	11.3 *Biology* • Understands what major organelles, and how do these impact cell function • Understands how do organisms obtain and use the matter and energy they need to live and grow • Understands what are the structural relationships among DNA, proteins, and genes • Understands how does o matter and energy move through an ecosystem • Understands how does the environment influence populations of organism over multiple generations • Understands how does organisms grow and develop 11.4 *Physics* • Understands what is energy and how is it measured • Understands how is energy transferred between objects • Understands how to model energy and energy changes at the particulate level • Understands the relationship between thermal energy and temperature • Understands how to make predictions of a objects' continued motion, changes in motion, or stability 11.5 *Engineering, Technology and Applications* ● Understands that the engineering design process begins with identifying a problem and developing clear goals that the final product or system must meet ● Understands the process for developing potential design solutions, including models or prototypes ● Understands how to compare and improve various proposed design solutions
12. Scientific Procedures and Techniques *Praxis (5245)*	12.1 Understands how to collect, evaluate, manipulate, interpret, and report data ● Significant figures in collected data and calculations ● Organization and presentation of data ● Knows how to interpret and draw conclusions from data presented in tables, graphs, and charts (e.g., trends in data, relationships between variable, predictions, and conclusions based on data)

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	12.2 Understands basic error analysis • Determining mean • Accuracy and precision • Identifying sources and effects of error and its impact on percent error
13. Disciplinary Literacy *AR DLS*	***Reading Standards for Literacy in Science and Technical Subjects, Grades 9-12*** 13.1 Reads science/technical texts closely to determine what the text says explicitly and to make logical inferences from it, while determining central ideas or themes and analyzing development by • Cites specific textual evidence to support analysis of science and technical sources, attending to such features as the date and origin of the information [Grades 9-10]; and cites specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account [Grades 11-12] • Determines the central ideas or conclusions of a text; traces the text's explanation or depiction of a complex process, phenomenon, or concept; provides an accurate summary of the text [Grades 9-10]; and determines the central ideas or conclusions of a text; summarizes complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms [Grades 11-12] • Follows precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text [Grades 9-10]; and follows precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyzes the specific results based on explanations in the text [Grades 11-12] 13.2 Interprets words and phrases as they are used in a historical/social studies texts, while analyzing the structure of such texts • Determines the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grade-specific texts and topics [Grades 9-12] • Analyzes the structure of the relationships among concepts in a text, including relationships among key terms [Grades 9-10]; and analyzes how the text structures information or ideas into

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categories or hierarchies, demonstrating understanding of the information or ideas [Grades 11-12]

- Analyzes the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address [Grades 9-10]; and analyzes the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved [Grades 11-12]

13.3 Integrates knowledge and ideas

- Translates quantitative or technical information expressed in words in a text into visual form (e.g., a table chart) and translate information expressed visually or mathematically (e.g., in an equation) into words [Grades 9-10]; and integrates and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem [Grades 11-12]
- Assesses the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem [Grades 9-10]; and evaluates the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information [Grades 11-12]
- Compares and contrasts findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts [Grades 9-10]; and synthesizes information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible [Grades 11-12]

3.4 Reads and comprehends science/technical texts in the Grades 9–10 text complexity band independently and proficiently by the end of Grade 10; reads and comprehends science/technical texts in the Grades 11–12 text complexity band independently and proficiently by the end of Grade 12

Writing Standards for Literacy in Science and Technical Subjects, Grade 9-12

13.5 Writes arguments to support claims when analyzing substantive topics or texts using valid reasoning and relevant, sufficient evidence;

	writes informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective; and writes narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences ● Writes arguments focused on discipline-specific content [Grades 9-12] ● Introduces precise claim(s), distinguishes the claim(s) from alternate or opposing claims, and creates an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence [Grades 9-10]; and introduces precise, knowledgeable claim(s), establishes the significance of the claim(s), distinguishes the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence [Grades 11-12] ● Develops claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns [Grades 9-10]; and develops claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases [Grades 11-12] ● Uses words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims [Grades 9-10]; and uses words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims [Grades 11-12] 13.6 Produces and distributes writing ● Establishes and maintains a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing [Grades 9-10]; and establishes and maintains a formal style and objective tone while attending to

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the norms and conventions of the discipline in which they are writing [Grades 11-12]

- Provides a concluding statement or section that follows from or supports the argument presented [Grades 9-12]
- Writes informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes [Grades 9-12]
- Introduces a topic and organize ideas, concepts, and information to make important connections and distinctions; includes formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension [Grades 9-10]; and introduces a topic and organizes complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension [Grades 11-12]
- Develops the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic [Grades 9-10]; and develops the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic [Grades 11-12]

13.7 Uses research to build and present knowledge:

- Conducts short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration [Grades 9-12]
- Gathers relevant information from multiple print and digital sources, using search terms effectively; assessing the credibility and accuracy of each source; quoting or paraphrasing the data and conclusions of other while avoiding plagiarism and following a standard format for citation [Grades 9-12]
- Draws evidence from information to support analysis, reflection, and research [Grades 9-12]

13.8 Writes routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences [Grades 9-12]

Reference: Beatty, Alexandra and Schweingruber, Heidi 2017; *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom*, National Academies Press, Washington DC

COSSS and Flinn Scientific, Inc. resource for high school chemical lab safety titled: *SCIENCE LAB & PREP AREA SAFETY GUIDANCE RESOURCE* (http://cosss.org/resources/Documents/CSSS-High-School-Science-Safety-May-2021.pdf)

14. DESE GUIDE for Life *GUIDE for Life*	***GUIDE for Life*** *The Arkansas Department of Education has identified five guiding principles that support educators in their efforts to help all students develop these critical skills. Each principle represents a set of skills needed to thrive at home, school, on the job and in the community. These guiding principles are:* 14.1 Growth (manages self) ● Develops problem-solving skills ● Practices mindfulness ● Perseveres 14.2 Understanding (knows self) ● Increases self-awareness ● Knows own strengths and weaknesses ● Develops critical thinking skills 14.3 Interaction (builds relationships) ● Treats others with respect ● Communicates effectively ● Seeks out and offers help when needed 14.4 Decisions (makes responsible choices) ● Considers personal beliefs ● Thinks through potential consequences ● Puts best self forward 14.5 Empathy (is aware of others) ● Sees other perspectives ● Values the feelings of others ● Appreciates diversity

New America= *2020 New America Teacher Competencies that Promote Culturally Responsive Teaching* **GUIDE for Life=** *2019 Arkansas Department of Education G.U.I.D.E for Life: 5 Skills for Personal Success* **NSTA/ASTE Standards=** *2020 National Standards for Science Teacher Preparation/Association for Science Teacher Education Standards for Science Teacher Preparation* **NSTA-C=** *Secondary Preservice Teacher Standards—Chemistry* **Praxis (5245) =***Praxis (5245): Chemistry: Content Knowledge* **NRC Framework** = *2012 National Research Council. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* **ARDLS=** *2016 Arkansas Disciplinary Literacy Standards, Grades 6-12* **ACS=** *2018 American Chemical Society Guidelines and Recommendations for Teaching Middle and High School Chemistry* **AR SS=** *2015-2016 Arkansas K-12 Science Standards*

Reference: Beatty, Alexandra and Schweingruber, Heidi 2017; *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom*, National Academies Press, Washington DC

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